SCIENCE

FRIDAY, JULY 26, 1912

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MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

SIR WILLIAM HERSCHEL[1]

DURING the last twenty years there has been a great revival of statistical investigations as to the distribution and motions of the so-called fixed stars. Kapteyn, of Groningen, is the leader of those who are renewing the attempt to obtain in this way some idea as to the construction of the universe. Earlier astronomers had of course done something in this direction, but the work of William Herschel so far transcends that of all others, that it would be fair to describe him as the originator of this class of investigation. It may be of interest to mention that a complete edition of his works is now in course of publication, under the direction of a joint committee of the Royal and Astronomical Societies.

The interest of Herschel's writings, and the simple charm of his style—written it is to be remembered in a language which was not his from birth—have led me on to read about the man as well as about his scientific work. Throughout his life's work his name is inseparable from that of his sister Caroline, and I hope it may prove of interest to you to hear of what they were as well as of what they did. They were born at Hanover, he in 1738, she in 1750, the children of a bandsman of the Hanoverian Guards. At the age of fifteen Herschel was already a member of the Guards' band. In 1757 the regiment, which had been in England for about a year, served in Germany during the Seven Years' War, and William seems to have suffered from the hardships of the cam-

[1] An address before the Royal Institution of Great Britain, given on April 26, 1912.

paign. His parents, seeing that he had not the strength for a soldier's life, determined to remove him from the regiment. The removal may be described more bluntly as desertion, for we learn that when he had passed the last sentinel at Herrenhausen, he took off his uniform and his luggage was secretly sent after him to Hamburg. At any rate, fortunately for science, he escaped, and in 1757 or 1758 made his way to England.

It would perhaps be impossible to follow him throughout his wanderings, but we know that he was at one time instructor of the band of the Durham Militia, and afterwards that he gained his living as a musician in Leeds, Halifax, Pontefract and Doncaster. In 1764 he even ventured back to Hanover for a short time, and thus saw his favorite sister again.

During her early years Caroline seems to have been practically the household drudge or general servant, and whatever she learned was by stealth or in the scanty intervals snatched from her household duties, for her mother thoroughly disapproved of education for a girl.

When we reflect on the difficulties under which both brother and sister labored, and then consider how much they were able to accomplish, we might be tempted to underrate the value of educational advantages. Concerning education, Bishop Creighton once said in my hearing, "It is surprising how little harm we do notwithstanding all the pains we take." Paraphrasing the remark, although spoiling the epigram, I would say, "It is surprising how little harm the lack of opportunity does to a great genius."

In 1766 William took a position as organist at Bath; then at the height of fashion. The orchestra at the Pump Rooms and at the theatre at Bath was then one of the best in the kingdom, and Elizabeth Linley, daughter of the director of the orchestra, was the prima donna of the concerts. When in 1771 she became engaged to Charles Sheridan, Herschel thought that the expected vacancy would make an opening for his sister at Bath, and suggested that she should join him. And, in fact, after a time such a vacancy did occur, for Elizabeth Linley, after flirting with Charles Sheridan, jilted him and eloped with and married the celebrated Richard Brinsley Sheridan.

Caroline was very anxious to accede to her brother's suggestion, but the rest of the family would not for a time hear of it. At length, however, in 1772, Herschel came to Hanover and carried off his sister with the mother's reluctant consent. Even from boyhood his intense love of astronomy had been manifest, and it is interesting to note that in passing through London on their way from Harwich to Bath, when they went out to see the town, the only sights which attracted their attention were the opticians' shops.

On Mr. Linley's retirement from the orchestra at Bath, Herschel became the director and the leading music-master in the town, and he thus obtained an established position. Although Caroline sang a little in public, her aspiration to become the prima donna of Bath was not fulfilled. But she was kept busy enough at first in the cares of housekeeping, with endless wrangling with a succession of incompetent slaveys, and then she gradually became more and more her brother's astronomical assistant.

In the midst of Herschel's busy musical life he devoted every spare moment to astronomy, and when his negotiations for the purchase of a small reflecting telescope failed—and they were all small in those days—he set to work to make mirrors for himself.

One room in the house was kept tidy for pupils, and the rest of the house, including the bedrooms, was a litter of lathes and polishing apparatus. He made reflecting telescopes not only for his own use, but also for sale, for the purpose of providing funds to enable him to continue his researches. His industry must have been superhuman, for later in his life he records that he had made over 400 mirrors for Newtonian telescopes, besides others of the Gregorian type. These mirrors ranged in diameter from a few inches to 4 feet, in the case of the great 40-foot telescope. I should say that mirrors are not specified by the diameter of the reflecting surface, but by the focal length. Thus, whatever may be the diameter of the reflecting surface, a 20-foot telescope means that the mirror is approximately portion of a sphere of 40 feet in radius, and this will give a focal length of 20 feet. You must, in fact, double the focal length of a telescope to find the radius of the sphere of which it forms a small part.

In order to learn anything of the making of reflectors it is necessary to go to original memoirs[2] on the subject, and even of them there are not many. I feel, therefore, that I shall not be speaking on a topic known to many of the audience if I make a digression on a singularly fascinating art. Mirrors are now made of glass with a reflecting surface of chemically deposited silver; formerly they were made of speculum metal, an alloy of copper and tin. Of whatever substance the mirror is made the process of working it to the required form is much the same. The most complete account of the process of which I know is contained in a paper by Professor G. W. Ritchey in Vol. 34 (1904) of the Smithsonian Contributions to Knowledge. He there gives a full description of the great reflector of the Yerkes Observatory. The process only differs from that employed by Herschel in that he worked by hand, whereas machinery is now required to manipulate the heavy weight of the tools. The Yerkes mirror is formed of a glass disk 5 feet in diameter, and it weighs a ton; the grinding tools are also very heavy.

I must pass over the preliminary operations whereby the rough disk of St. Gobain glass was reduced to a true cylindrical form, smooth on both faces and round at the edge. Nor will I describe the grinding of a shallow depression on one of the faces by means of a leaden tool and coarse emery powder.

It will be well to begin by an account of the manufacture of the tools wherewith the finer grinding and polishing is effected, and then I shall pass on to a short description of the way they are used.

Two blocks of iron are cast with the desired radius of curvature, the one being concave and the other convex. The castings are then turned so that the concavity and convexity fit together as nearly as may be. For the large mirror these blocks are a little over 2 feet 6 inches in diameter, but for small ones they are made of the same diameter as the mirror to be ground. The two are then ground together for a long time with emery powder and water until every part of one surface fits truly to every part of the other. They must then both be portions of a sphere of the same radius, because the sphere is the only surface in which a universal fit is possible. The concave iron is very precious because it furnishes the standard for regrinding the convex grinding tools when they have become worn by use. In order to make a plane mirror, three surfaces are ground

[2] Sir Howard Grubb's lecture at the Royal Institution in 1887 is one of these, Vol. XI., p. 413. Lord Rosse's papers are amongst the most important.

two and two, for if *A* fits *B* and *C*, and *B* fits *C* all over each surface they must all be true planes. However, I shall only speak of the figuring of concave mirrors.

The roughly hollowed glass disk is now laid on several layers of Brussels carpet centrally on a massive horizontal turn-table. The convex iron tool just described is suspended by a universal joint from a lever, and it is counterpoised so that only a portion of the weight of the tool will rest on the glass when it is in use. A complicated system of cranks and levers is so arranged that the tool can be driven by machinery to describe loops or curves of any arbitrarily chosen size over the glass, and as these loops are described by the tool the turn-table turns round slowly. In this way every part of the tool is brought into contact with every part of the glass disk in a systematic way. When working near the edge a large part of the tool projects beyond the edge of the glass.

Emery powder and water are supplied in a way I need not describe, and the tool is lowered gently on to the glass. The motive power is then applied, and the grinding is continued for many hours until the preliminary rough depression has been hollowed to nearly the desired shape—namely, that of the standard concave iron.

For finer grinding a change of procedure is now adopted, and very finely powdered emery is used. Another convex tool is formed, by grinding with the standard concavity; the working face of the tool is, however, now cut up into small squares by a criss-cross of narrow and shallow channels. Such channels are found to be necessary in order to secure an even distribution of the emery and water all over the surface. The grooved tool is now used for many hours, and the surface is tested at frequent intervals with a spherometer. The work ceases when it is no longer possible to detect errors of curvature in this way.

The next stage is polishing. The thickness of the layer of glass worn off in polishing is to be estimated in ten-thousandths of an inch, and can scarcely be detected even with the finest spherometer. For polishing the iron tool is discarded and the work is carried on by hand. As lightness is essential, the tool is built up by a stiff lattice-work of wood with a continuous wooden working face. It is obvious that however carefully the face may be turned it can not be made sufficiently true, and the requisite accuracy is obtained by means of the plastic properties of rosin or pitch. A number of squares of rosin about a quarter of an inch thick and an inch square are made, and these are glued in rows on the convex face of the wooden tool, with a narrow space intervening between each rosin square and its neighbors. The tool is then warmed slightly so as to soften the rosin a little, and it is then pressed lightly on to the glass disk. By means of this "warm-pressing" a nearly perfect fit is attained.

Each of the rosin squares is then painted with hot melted wax. This is done because wax is harder than rosin and affords a better working face. Finally, when the tool is quite cold, the surface of the glass is painted all over with very finely powdered rouge and water, and the tool is placed gently on the glass with some additional weight resting on it. It is left thus for several hours, but is moved slightly every ten minutes to ensure an even distribution of the rouge and water. By means of this "cold-pressing" a perfect fit is secured of the wax-coated rosin squares with the glass face. Cold-pressing has to be repeated every day before the work begins.

The polishing is now carried on in much the same way as the grinding, but by hand instead of by machine power. The turn-table can be made to tilt so as to bring the

glass to stand vertically, instead of horizontally, and the disk is frequently tilted up so as to submit the surface to optical tests. These latter tests are far more searching than those with a spherometer, and enable the observer to detect an error in the radius of curvature of portion of the reflector of a hundredth of an inch. To correct such an error it will be necessary to remove a layer of glass of $\frac{1}{500000}$ths of an inch!

The most refined optical test is by the observation of the image of a brilliant light issuing from a pin-hole close to the intended center of the spherical surface. The observer examines the image of the pin-hole with a microscopic eye-piece placed as close as possible to the pin-hole. He then causes a straight-edge close in front of the eye-piece to move slowly across the reflected beam of light, either from left to right or from right to left, so as to eclipse the light. Previously to the eclipse the whole of the glass seems to be a uniform blaze of light, and if the curvature is perfect the light which enters the observer's eye comes from all parts of the disk, and the surface is seen to darken equably all over. But if the surface is imperfect the light from some part is eclipsed sooner than that from others, and the disk seems to possess considerable hills and valleys illuminated, as it were, by a setting sun.

The interpretation of these apparent hills and valleys shows where further local polishing with a small tool is requisite. Sir Howard Grubb says that if he suspects a hollow, he holds his hand near the surface for a minute or two; if a hill is suspected, he washes the region with an evaporating wash. The warmth in the one case and the cooling in the other tend to rectify, and indeed over-rectify, the errors.

When success is finally attained, after all we have only a spherical surface, and it becomes necessary to obtain a parabolic form. This last stage is done by further tests of the kind described, with a diaphragm placed over the mirror which only permits the observer to see the light reflected from chosen zones of the mirror. The time at my disposal will not allow me to describe this in further detail, or to tell you how there is always found to be one definite diameter of the glass along which its weight must be supported. I must pass by, too, the system of counterpoised levels used for supporting the back of the glass, and the method by which silver is chemically deposited on its surface. Meager although this sketch has been, it will have served to show you how beautiful are the processes employed, and I would ask you to realize that at first Herschel was a mere amateur, and had to discover everything for himself.

As I have said, Hershel had to do all his polishing by hand, and he found when once the final stage had begun, it was necessary that it should never stop even for a moment. Caroline relates how she was kept busy in attending on her brother when polishing:

> Since by way of keeping him alive I was constantly obliged to feed him by putting the victuals by bits into his mouth. This was once the case, when in order to finish a 7-ft. mirror, he had not taken his hand from it for sixteen hours together.

The making of the mirror is, however, but a small part of the difficulty of making a telescope, for it involves high engineering skill to provide a solid stand, an observing platform, the graduated circles in right ascension and declination for setting the telescope and the clock, whereby it is made to follow the stars in their daily motion. The great size of Herschel's mirrors and the weight of the long tube introduced mechanical difficulties which were at that time entirely new.

A dozen years after his establishment at Bath, Herschel began to be well known in the world of science, and many of the most illustrious astronomers came to see him. In 1781 he was elected to the Royal Society, and in the same year he discovered the planet Uranus, and called it by the now almost forgotten name of Georgium Sidus, in honor of George III. The magnitude of the discovery may be estimated by the fact that only the five principal planets, familiar to all men for centuries, were then known; and the asteroids or minor planets had not yet been discovered by Herschel himself. His fame from this and his other discoveries led to a command from the King to take his 7-foot telescope to Windsor, and there he was requested to act as celestial showman to the King, the Queen, and the Princess. The expedition put him to much expense, and he was kept hanging about Windsor for months, but at length the King offered him the post of private royal astronomer, with the modest salary of £200 a year.

Herschel's friend, Sir William Watson, said that never had a monarch bought honor so cheap, and Caroline pours scorn on the king's meanness; but I think this was hardly fair. It must have been well known that Herschel had deserted from the Hanoverian Guards, and while the King might consent to forget this, it was a strong measure to take the deserter into his service. At a later date, moreover, when the King was informed by Sir Joseph Banks of Herschel's financial difficulties, he granted him £2,000, afterwards increased to £4,000, for the construction of the great 40-ft. telescope, with the condition that he should retain it for his own use. To this was added a further £200 a year for maintenance, and a pension of £50 a year to Caroline Herschel. And besides he was allowed to make specula for sale, and half the observatories of Europe were so furnished by him at prices which were then thought considerable.

At any rate Herschel jumped at the offer, which, by relieving him from his musical slavery, allowed him to follow the wish of his life. The Herschels then came to the neighborhood of Windsor, and after several removals they finally settled at Slough. The change was delightful for him, since he now had space for his telescopes and workshops, but the difficulties of housekeeping in a rambling and dilapidated house rendered the change somewhat less agreeable to his sister.

The closeness to Windsor was perhaps a necessity of the case, but it had its disadvantages, since he was frequently summoned to take his telescope to Windsor, or large parties from the castle would visit him at his house in order to see the wonders of the heavens. When his time had been wasted in this way he would make up for the loss by redoubled labor.

The fury, as I may call it, with which they worked may be gathered from Caroline's journal, and the work was not free from danger, because in his eagerness Herschel would not always delay his observations until the telescope was properly fixed. To stand in the dark on a platform without a railing, when your attention is distracted from your position, can not be very safe, and they both met with a good many accidents which might easily have proved fatal.

The incessant work, together with the interruptions by the visitors from the castle, began at length to tell on Herschel's health. His sister notes that on the 14th of October, 1806, after working all day, he was out from sunset till past midnight surrounded by fifty or sixty persons, without food or proper clothing, and that he never

seemed to recover completely from this great strain on his strength.

But I have passed by an event of importance in the lives of both brother and sister, for in 1783 he married Mrs. Pitt, a lady of singularly amiable and gentle character. To the sister, however, the marriage was a great blow, for, although she continued to be his secretary and assistant, she moved into neighboring lodgings, and was no longer so closely associated with him as theretofore. Mrs. John Herschel writes: "It is not to be supposed that a nature so strong and a heart so affectionate should accept the new state of things without much and bitter suffering," and tradition confirms this belief. All her notes and memoranda relating to a period of fifteen years from the time of the marriage were destroyed by her when, as we may presume, her calmer judgment showed her that the record of her heart-burning would be painful to the surviving members of the family. At any rate, she was on affectionate terms with her sister-in-law throughout all the later years of her life, and the brilliant career of her nephew, the celebrated Sir John Herschel, and correspondence with him, afforded the leading interest of her old age.

Although Herschel lived until 1822, and accomplished an enormous amount of work up to the end of his life, yet his health seems to have declined from about the time I have noted. On his death Caroline felt that her life, too, was practically ended and she returned to Hanover. Ever afterwards she used to cry, "Why did I leave happy England?" and it is incomprehensible that she should not have returned to the place where all her real interests lay.

Although she felt the death of her brother as practically the end of her life, she was always full of jokes and fun. In a letter to her nephew, she told him that her father used to punish her, a grown woman, by depriving her of her pudding if she did not guess rightly the angle of the piece she had helped herself to. Dr. Groskopf writes of her when she was eighty-nine years of age:

> Well! what do you say of such a person being able to put her foot behind her back and scratch her ear with it, in imitation of a dog, when she was in one of her merry moods?

She only died in 1847, having very nearly completed her ninety-eighth year.

Herschel himself must have been a man of singular charm, as is testified to by Dr. Burney and his daughter Mme. d'Arblay. That he possessed an incredible amount of patience is proved by the fact of his submitting to the reading aloud of the whole of a portentous, and fortunately unpublished, poem in many cantos by Dr. Burney, entitled "A Poetical History of Astronomy." It appears that Herschel had had an interview with Napoleon in Paris in 1802, and the poet Campbell asked him whether he had been struck by Napoleon's knowledge. Said Herschel:

> No, the First Consul surprised me by his versatility, but in science he seemed to know little more than any well-educated gentleman, and of astronomy much less, for example, than our king. His general air was something like affecting to know more than he did know.

He was struck, too, by Napoleon's hypocrisy in observing "how all these glorious views gave proofs of Almighty Wisdom."

And now having endeavored to show what kind of people Caroline and her brother were, I must turn to what they did. Herschel's discoveries were so numerous that I am compelled to make a selection. I shall therefore only attempt to sketch his endeavor to understand the general construction of the stellar universe, and to speak of his work on double stars.

The only general test of the relative nearness or farness of the stars is their brightness, because the faint stars must, on the average, be more distant than the bright ones. Herschel then proposed to penetrate into space by means of a celestial census of the distribution and of the brightness of the stars. With this object he carried out four complete reviews of the heavens, as far as they may be seen from our latitude, passing successively to the fainter and fainter objects by means of the increased size of his telescope.

He divided the heavens into sweeps 2° 15′ of breadth in declination, and each zone was examined throughout by the process which he called star-gauging. His census was made with the 20-ft. reflector, with which instrument the field of view was about one quarter of the size of the full moon. It needs over 300,000 of such fields of view to cover the whole of the hemisphere of space, and Herschel surveyed the whole northern hemisphere, and as much of the southern one as he could.

Von Magellan in a letter to Bode describes the method of observation as follows:

> He has his 20-ft. Newtonian telescope in the open air. . . . It is moved by an assistant who stands below it . . . near the instrument is a clock . . . in the room near it sits Herschel's sister, and she has Flamsteed's Atlas open before her. As he gives her the word, she writes down the declination and right ascension. . . . In this way Herschel examines the whole sky . . . he is sure that after four or five years (from 1788) he will have passed in review every object above our horizon. . . . Each sweep covers 2° 15′ in declination, and he lets each star pass at least three times through the field of the telescope, so that it is impossible that anything can escape him. . . . Herschel observes the whole night through . . . for some years he has observed . . . every hour when the weather is clear, and this always in the open air.

Herschel points out that by this survey he was not only looking into the most distant space, but also into the remotest past, for the light of many of the stars must have started on its journey towards us thousands or even millions of years ago. The celestial museum therefore exhibits to us the remotest past alongside with the present, and we have in this way the means of reconstructing to some extent the processes of evolution in the heavens. In photography the modern astronomer possesses an enormous advantage, but Herschel laid the foundation of this branch of astronomy without it.

The most conspicuous and the most wonderful object in the heavens is the Milky Way. It runs all round the skies in a great band, with a conspicuous rent in it forming a streamer which runs through many degrees. To the naked eye it shines with a milky light, but Herschel was able to show that it consists of countless stars in which there lie embedded many fleecy nebulæ. There is good reason to believe that the Milky Way on the whole consists of stars which are younger than those in the other parts of space, for the stars in it are whiter and hotter, and the nebulæ are mostly fleecy clouds. On the other hand, the spiral and planetary nebulæ are more frequent away from the Milky Way, and these are presumably older than the cloudy and flocculent nebulæ. The shape of the Milky Way seems to resemble a huge millstone or disk of stars, and since it forms a complete circuit in the heavens the sun must lie somewhere towards its middle. It is probable that we look much further out into space along this tract than elsewhere, although it happens that by far the nearest of all the stars—namely, α Centauri—lies in the line of the Milky Way.

This great congregation of stars is far from uniform in density, for there are places in it where there are but few stars or none at all. Caroline Herschel, writing

to Sir John Herschel at the Cape of Good Hope, in 1833, mentions that her brother, when examining the constellation of the Scorpion (which lies at best low down on our horizon), had exclaimed, "after a long, awful silence, 'Hier ist wahrhaftig ein Loch im Himmel.'" And her nephew, as he said, rummaged Scorpio with the telescope and found many blank spaces without the smallest star.

It will explain some of the deductions which Herschel drew from his star-gauges, and will at the same time furnish a good example of his style, if I read a passage from a paper of his written in 1789.[3] He points out that the sun is merely a star, and, referring to the stars, he continues thus:

> These suns, every one of which is probably of as much consequence to a system of planets, satellites and comets, as our own sun, are now to be considered in their turn, as the minute parts of a proportionally greater whole. I need not repeat that by my analysis it appears that the heavens consist of regions where suns are gathered into separate systems, and that the catalogues I have given comprehend a list of such systems; but may we not hope that our knowledge will not stop short at the bare enumeration of phenomena capable of giving us so much instruction? Why should we be less inquisitive than the natural philosopher, who sometimes, even from an inconsiderable number of specimens of a plant, or an animal, is enabled to present us with the history of its rise, progress and decay? Let us then compare together, and class some of these numerous sidereal groups, that we may trace the operations of natural causes so far as we can perceive their agency. The most simple form, in which we can view a sidereal system, is that of being globular. This also, very favorably to our design, is that which has presented itself most frequently, and of which I have given the greatest collection.
>
> But, first of all, it will be necessary to explain what is our idea of a cluster of stars, and by what means we have obtained it. For an instance I shall take the phenomenon which presents itself in many clusters. It is that of a number of lucid spots, of equal luster, scattered over a circular space, in such a manner as to appear gradually more compressed towards the middle, and which compression, in the clusters to which I allude, is generally carried so far, as, by imperceptible degrees, to end in a luminous center of an irresolvable blaze of light. To solve this appearance it may be conjectured that stars of any given very unequal magnitudes may easily be so arranged, in scattered, much extended, irregular rows, as to produce the above described picture; or, that stars, scattered about almost promiscuously within the frustum of a given cone, may be assigned of such properly diversified magnitudes as also to form the same picture. But who, that is acquainted with the doctrine of chances, can seriously maintain such improbable conjectures?

Later in the same paper he continues:

> Since then almost all the nebulæ and clusters of stars I have seen, the number of which is not less than three and twenty hundred, are more condensed and brighter in the middle; and since, from every form, it is now equally apparent that the central accumulation or brightness must be the result of central powers, we may venture to affirm that this theory is no longer an unfounded hypothesis, but is fully established on grounds which can not be overturned.
>
> Let us endeavor to make some use of this important view of the constructing cause, which can thus model sidereal systems. Perhaps, by placing before us the very extensive and varied collection of clusters and nebulæ furnished by my catalogues, we may be able to trace the progress of its operation in the great laboratory of the universe.
>
> If these clusters and nebulæ were all of the same shape, and had the same gradual condensation, we should make but little progress in this enquiry; but as we find so great a variety in their appearances, we shall be much sooner at a loss how to account for such various phenomena, than be in want of materials upon which to exercise our inquisitive endeavors.
>
> . . . . . .
>
> Let us, then, continue to turn our view to the power which is molding the different assortments of stars into spherical clusters. Any force, that acts uninterruptedly, must produce effects proportional to the time of its action. Now, as it has been shown that the spherical figure of a cluster of stars is owing to central powers, it follows that those clusters which, *ceteris paribus*, are the most

[3] *Phil. Trans.*, Vol. LXXIX., p. 212.

complete in this figure, must have been the longest exposed to the action of these causes. This will admit of various points of view. Suppose, for instance, that 5,000 stars had been once in a certain scattered situation, and that other 5,000 equal stars had been in the same situation, then that of the two clusters which had been longest exposed to the action of the modelling power, we suppose would be most condensed, and more advanced to the maturity of its figure. An obvious consequence that may be drawn from this consideration is that we are enabled to judge of the relative age, maturity or climax of a sidereal system, from the disposition of its component parts; and, making the degrees of brightness in nebulæ stand for the different accumulation of stars in clusters, the same conclusions will extend equally to them all. But we are not to conclude from what has been said that every spherical cluster is of an equal standing in regard to absolute duration, since one that is composed of a thousand stars only must certainly arrive to the perfection of its form sooner than another which takes in a range of a million. Youth and age are comparative expressions; and an oak of a certain age may be called very young, while a contemporary shrub is already on the verge of its decay. The method of judging with some assurance of the condition of any sidereal system may perhaps not improperly be drawn from the standard laid down earlier; so that, for instance, a cluster or nebula which is very gradually more compressed and bright towards the middle may be in the perfection of its growth, when another which approaches to the condition pointed out by a more equal compression, such as the nebulæ I have called *Planetary* seem to present us with, may be looked upon as very aged, and drawing on towards a period of change, or dissolution. This has been before surmised, when in a former paper I considered the uncommon degree of compression that must prevail in a nebula to give it a planetary aspect; but the argument which is now drawn from the powers that have collected the formerly scattered stars to the form we find they have assumed, must greatly corroborate that sentiment.

This method of viewing the heavens seems to throw them into a new kind of light. They now are seen to resemble a luxuriant garden, which contains the greatest variety of productions, in different flourishing beds; and one advantage we may at least reap from it is, that we can, as it were, extend the range of our experience to an immense duration. For, to continue the simile I have borrowed from the vegetable kingdom, is it not almost the same thing, whether we live successively to witness the germination, blooming, foliage, fecundity, fading, withering and corruption of a plant, or whether a vast number of specimens, selected from every stage through which the plant passes in the course of its existence, be brought at once to our view?

I now turn to another line of discovery of which I can not show any pictures, but which, to me at any rate, is more interesting. Until 1838—that is to say, until sixteen years after Herschel's death—no one had succeeded in determining the distance of a single fixed star, but in that year Henderson and Bessel almost simultaneously attained success in the cases of the two stars α Centauri and 61 Cygni. The attempts at this measurement had already been numerous, and Herschel amongst others had failed, but his failure was a glorious one, for he made incidentally a discovery of another kind and of at least equal interest.

The earth moves around the sun at a distance of 93 million miles, so that in six months we shift our position by 186 million miles. If, then, there are two stars of which one is relatively near to and the other far from the sun, but so situated as to appear to us very close together, the near one ought to shift its position relatively to the distant one in the course of each six months. The amount of this change of position, called by astronomers annual parallax, should furnish the distance of the nearer of the pair, provided that the other is very far off. This idea is as old as the time of Galileo, but no one had been able to make successful use of it.

As I have already said, the only general test of the distance of a star is its brightness, and therefore Herschel chose pairs of stars of very different brilliancy. He thought, at least at first, that it was mere chance which brought the stars so near to

one another, and there are undoubtedly such pairs now known as "optically double stars." But Herschel's mode of attack was bound to fail if the seemingly neighboring stars were really so, and were linked together by their mutual gravitation. Already as early as 1707 Michel had suggested the existence of such true double stars, but it was Herschel who proved their existence. His first catalogues of double stars, published in 1782, contained 203 cases of such doublets, and he already suspected a community in their motions explicable only by their real association; but by 1802 he had become certain. In many cases the two components of a binary pair were found to be moving in nearly the same direction and at the same speed, but superposed on this motion of the system as a whole there was an orbital motion of one star round the other. Herschel even lived long enough to see some of his pairs of stars perform half a revolution about one another.

After his death Savary took the matter one stage further, and showed that the revolution was governed by the laws of gravity, and thereby confirmed the truth of Herschel's belief. Thus the failure to measure the distance of stars led to the proof that gravity reigns amongst the stars as in the solar system.

Arago thought that of all Herschel's discoveries this was the one that had the greatest future, and his prophecy has proved singularly correct. Every year adds to the number of double stars, whose orbits are now accurately determinable. These systems are found to be very unlike our own solar system, for the component stars are, in many cases, far larger than the sun and revolve about one another in periods which, in various cases, may be either many years or only a few hours.

The spectroscope has, moreover, added enormously to our knowledge, for the speed of approach or recession of a star from the sun can now be determined as so many kilometers per second. Thus that component of the motion of a star which was concealed from Herschel is now known with the greater certainty. Moreover, being ignorant of the distance of the stars, he could only express the transverse component of motion in seconds of arc.

A wonderful corollary also results from the use of the spectroscope, namely, the existence of many stars known as "spectroscopic binaries." As seen even with the most powerful telescope such a star is a single point of light, but if the spectral lines are duplicated we know that the source of light is double, and that one component is approaching us and the other receding from us. In this way the orbits and relative masses of these visually inseparable stars are determinable. The number of known double stars, including both visual and spectroscopic ones, is already large, and Campbell, of Lick Observatory, has expressed his opinion that one star in six is double. Some of them revolve so near to one another and in such a plane that they partially eclipse one another as they revolve, and thus produce a winking light like that of a lighthouse. It would seem that we can now even tell something of the shapes of a pair of stars visually inseparable from one another. But I must not go further into this subject, and will only repeat Arago's saying, that this discovery of Herschel's has "le plus d'avenir."

It is a figure of speech to refer to the stars as fixed, for a large number of them possess a measurable amount of "proper motion" relatively to their neighbors. The existence of double stars was discovered by the observation of their movements, and thus the study of proper motions is linked

to the subject of which I have just been speaking. Some few proper motions had been observed by earlier astronomers, but when Herschel took up the subject proper motion had not been accurately measured in any case.

If a man is walking through a wood the trees in front of him seem to be opening out before him, whilst those behind seem to be closing together. In the same way if our sun is moving relatively to the center of gravity of all the stars, the stars must on the average seem to move away from the point towards which the sun is travelling, whilst they must close in towards its antipodes. These two points are called the apex and antapex of the sun's path.

Now Herschel concluded that there was something systematic in the proper motions of the stars, and that there was a point in the constellation of Hercules from which the stars were on an average receding, and that similarly they were closing in towards the antipodal point. The first of these is the sun's apex and the second the antapex. These conclusions were drawn from the motions of comparatively few stars, but the result has been confirmed subsequently from a large number. Moreover, we have now learned by means of the spectroscope that we are travelling towards Hercules at the rate of about sixteen miles a second.

During these last few years this grand discovery of Herschel's has gained a great extension at the hands of Kapteyn and of many others, and it has been proved that other systematic motions of the stars are discoverable. The time at my disposal will not permit me to pursue this subject further, but I may say that it now appears that if we could view the universe from the center of gravity of the stars of the Milky Way, we should see a current of stars coming from a definite direction of space and penetrating our system.

What a vista of discoveries do these ideas open up to the astronomer! Some centuries hence the sun's apex may have shifted, and we may perhaps learn that the solar system is describing the arc of some colossal orbit. The drift or current of stars may also have begun to change its direction, and our descendants may have begun to make guesses as to its future course and as to its meaning. But whatever developments the future may have in store, we should never forget that the foundation of these grand conceptions of the universe was laid by Herschel. Holden ends his "Life of Herschel" with words which may also serve as a fitting end to my lecture:

> As a practical astronomer he remains without an equal. In profound philosophy he has few superiors. By a kindly chance he can be claimed as the citizen of no one country. In very truth his is one of the few names which belong to all the world.

GEORGE H. DARWIN

PAUL CASPAR FREER. AN APPRECIATION

IT is only a little over a decade since America broke out of her chrysalis and took flight into the large world beyond the range of her time-honored coast lights and began to shake off a little of her provincialism. At her farthest outpost she was fortunate in having sent out many able men. Among those was Paul Caspar Freer, who for ten years has been the director of the Bureau of Science of the government of the Philippine Islands. He went there at a time when the kings and captains had not yet departed and before the shouting had entirely died away. His work was not to run down *ladrones* nor to lend a voice to the tumult incident to a period of reconstruction. He set to work, with little funds and no sympathy, save from a very few, to organize what has become to-day the leading scientific organization in the orient. The writer, who is proud of having served under Dr. Freer for six years, knows what he went through, in that time; of the bitter opposition

and criticism he had to stand, not only from some of the natives (they must be forgiven), but from many of his countrymen, who ought to have known better (which can be forgiven, but not so easily).

Dr. Freer brought to his work a superb training, M.D. at Rush Medical and Ph.D. at Munich, a large view of scientific problems and their practical bearing and an almost painful regard for accuracy and detail, which I sometimes think can be got only in the German schools. I think I am safe in saying that Dr. Freer read and read carefully (and some of us know how ruthlessly) every article on whatever subject which has appeared in the *Philippine Journal of Science,* through the six years of its existence. This is the thing he lived for, and I have had the satisfaction of knowing that this journal is highly regarded in Europe and that over there he was one of the best known of all Americans in the east. But not so in America, where, I regret to say, the ignorance of our own possessions is surprising.

When the man in the street, the "get-rich-quick" schemer and some of the politicians were striving to commercialize the work of the bureau and pressure was being brought to bear on the staff, in that time when ideals in our work seemed about to suffer, when we young and inexperienced ones were in danger of losing sight of the lasting results, the work that would tell, the tall gray-haired familiar figure would loom up in the doorway and then would ensue such a talk as only a big man, a real scientist, can give, and we would take heart again. Those were times of great inspiration to us, and now that his voice will no longer be heard in those halls, we must live on the memory of it. How soon everything becomes a memory!

The work of the bureau will continue, another hand will guide, may be in a larger way still, or in a smaller way; but we, the workers, at least will miss the master.

Dr. Freer had not been well for the last two years, and after returning from a trip with the Secretary of the Interior, the Honorable Dean C. Worcester, into northern Luzon, where he hoped to recuperate, died in Baguio, on April 18, at a little over fifty years of age.

WARREN D. SMITH

May, 1912

THE MASTER'S DEGREE AT RUTGERS COLLEGE

UPON unanimous recommendation of the faculty the trustees of Rutgers College at their recent meeting adopted the following report of the faculty committee on graduate degrees:

Your committee on graduate degrees submits for the consideration of the faculty and for its action the following principles and consequent changes of policy in the granting of the master's degree, and recommends their adoption:

Two principles stand foremost: first, the master's degree should be given a distinct and definite place among academic honors; secondly, the degree should be held in the esteem due a higher degree. Those colleges and universities which grant it to graduate students only after at least one year's residence have thereby tried to restore it to honor, but they have failed to give it a distinct place, for it is usually merely a preliminary step towards the doctor's degree, to be forgotten if that degree is won, or to be a consolation to those who fail. In short, the course of study, the method of study and the aim of the student, all make it a doctor's degree of an inferior type; and as such it is often a reproach to the student in later years if it remains his final higher degree. On the other hand, those universities and colleges which grant it *in absentia* or after the completion of courses in medicine, law or divinity are either making it still less honorable or are making it a second degree for precisely the same work and both superfluous and meaningless. This is felt so generally to-day among able and right-minded students that few are willing to seek the degree under these latter conditions.

To the small college belongs especially, we believe, the task of rehabilitating this degree. Few small colleges are in a position to give adequate courses and facilities of research to candidates for the doctor's degree and it is often their duty to urge such students to go elsewhere; whereas, in the case of the master's degree, provided this degree is rehabilitated properly, the small college may be able to offer excellent opportunities to the student, to do so without great cost to the treasury

of the college, and to compete successfully with the larger universities.

Finally, it is the belief of your committee that there are an increasing number of men and women graduating from our colleges who are not fitted or who do not wish to devote themselves to the longer and profounder study and original research required for the doctor's degree, but who do desire to pursue further their college studies in some chosen direction and who might do so with great profit to themselves and to the community; especially is this true of those young men and women who intend to teach in the elementary and secondary schools and of those students who are about to enter our theological seminaries. Moreover, it is our belief that a few men in each year's graduating class at Rutgers belong to this group and should be encouraged to study at Rutgers for the higher degree. We have already three fellowships for whose administration we are responsible and we should no doubt be glad to receive further endowments of this sort.

Hence it seems to us both fitting and progressive that Rutgers College should seek to solve, for itself at least, this rather puzzling academic problem.

We recommend:

First, that the master's degree be regarded by the faculty of Rutgers College as a degree to be given after extended liberal study and not, as in the case of the doctor's degree, after intense application to one subject and to original research;

Secondly, that the studies pursued by the candidate for this degree constitute a distinct course by themselves as they would if he were studying law or divinity;

Thirdly, that this course consist of three subjects to be pursued by the student for two years, ordinarily in residence at Rutgers; equivalent graduate courses pursued at another institution may, however, be substituted for the first year's requirements;

Fourthly, that the character of such studies shall not differ essentially from that of the elective courses now widely offered to seniors in our colleges; in other words, that their character should be elementary and liberal;

Fifthly, that no student graduating from Rutgers College after 1912 be granted the master's degree on the basis of the present requirements.

Submitted to the faculty April 19, 1911.

Austin Scott,
J. Volney Lewis,
Walter T. Marvin,
Committee

MUSEUM BUILDINGS IN THE UNITED STATES

The writer has recently taken occasion to tabulate some statistics on museum buildings in the United States. The data were taken from the Directory of American Museums published two years ago by the Buffalo Society of Natural History. Table I. shows the source of the money with which museum buildings were erected. Table II. shows the years, by decades, the money was given or appropriated for museum buildings. Table III. shows the distribution of museum buildings in five groups of states. A map which was also prepared shows the location of the buildings. While the data given in the Buffalo publication are quite complete, it is evident that no tables like these can be perfectly accurate. They are, nevertheless, very instructive.

TABLE I

Decades	Number of Museums	Amounts Received
1840–1849	1	$ 20,000
1850–1859	2	34,000
1860–1869	6	1,277,000
1870–1879	7	6,030,000
1880–1889	5	560,000
1890–1899	20	9,866,000
1900–1909	21	14,224,000
Unknown		5,221,000

TABLE II

Sources of Funds	Number of Museums	Amounts Received
Private donations	36	$18,958,000
Universities (indirectly some states)	15	1,382,000
Cities	10	8,599,000
State and national governments	3	7,350,000
Other sources	1	943,000

TABLE III

Groups of States	Number of Museums	Cost of Buildings
Middle Atlantic States (6)	16	$17,478,000
North Central States (15)	16	8,466,000
New England States (6)	19	4,910,000
District of Columbia	2	4,400,000
Rocky Mountain and Pacific States (11)	10	1,836,000
Southern States	2	142,000

It is evident that the growth of our museums is largely parallel with the growth of

our national wealth and with the progress of higher education in our own country. It is during the last fifty years that American universities have begun to provide adequate facilities for higher education of the American youth. Museum building suffered a notable decline during the eighties. This was a period of active industrial development and of immigration into the Great Plains and to the west. To the writer the rapidly rising series of figures in the first table suggests the initial rapid growth of a great and strong nation *in its infancy*. Individual growth is most rapid at first.

ing of living truths in the human intellect by the collection and care of what the average hard-headed business man would scorn as "dry bones."

Table III. and the map indicate roughly the geographic distribution and the course of westward travel of the scientific mind of our nation. It has blazed a trail from Boston via New York and Philadelphia, to San Francisco. They show also the lingering effects of the world's most cruel war. Museums are the creations of intellect and wealth. Our great civil war destroyed the wealth of the south. Hence the insignificant sum spent for mu-

The irregularities in the series show that it does not represent the activities of any great number of individuals. The series is clearly an expression of a few potent factors, psychic, inscrutable forces, acting through the medium of exceptional men. And it is well known that the average man, the average man of wealth included, is not a prophet. It requires a prophet's instincts and faith to make enormous investments looking to the awaken-

seums in the south. A large vacant area appears in the southwest. The straight lines on the map, radiating from a point in the south part of this space, show the shortest distances to the nearest museums, where a naturalist in this region can take his collection for study. The indices at the proximal ends of these lines point to a place where the great museum of the southwest should be reared, a modern temple of science on the

Mediterranean of the Occident. Here is an exceptional opportunity for the exceptional man. Will he see it?

J. A. Udden

Austin, Texas,
April 15, 1912

REGENTS OF THE SMITHSONIAN INSTITUTION

Dr. Andrew D. White has been reappointed, by joint resolution of congress, as a regent of the Smithsonian Institution for six years. Dr. White received his first appointment to this office in the year 1888 and upon the completion of the present term he will have served the institution for thirty years. The vacancy in the board caused by the resignation of Dr. James B. Angell, ex-president of the University of Michigan, who was a regent from January 19, 1887, to January 15, 1912, has been filled by congress by the appointment of the Honorable Charles W. Fairbanks. With the appointments mentioned, the roll of regents is now complete. It is as follows: James S. Sherman, Vice-president of the United States, chancellor; Edward D. White, Chief Justice of the United States; Shelby M. Cullom, member of the Senate; Henry Cabot Lodge, member of the Senate; Augustus O. Bacon, member of the Senate; John Dalzell, member of the House of Representatives; Scott Ferris, member of the House of Representatives; Irvin S. Pepper, member of the House of Representatives; Andrew D. White, citizen of New York; Alexander Graham Bell, citizen of Washington, D. C.; George Gray, citizen of Delaware; Charles F. Choate, Jr., citizen of Massachusetts, John B. Henderson, Jr., citizen of Washington, D. C.; and Charles W. Fairbanks, citizen of Indiana.

SCIENTIFIC NOTES AND NEWS

Jules Henri Poincaré, the great mathematician and man of science, died on July 17. He was born at Nancy on April 29, 1854.

The University of Oxford has conferred the degree of D.Sc. on the following foreign delegates attending the celebration of the 250th anniversary of the foundation of the Royal Society: Dr. Backlund, director of the Imperial Observatory, Pulkowa; Dr. Brögger, professor of mineralogy and geology at Christiania and rector of the university; Professor Lippmann, president of the Académie des Sciences, Paris; Professor Scott, Blair professor of geology and paleontology at Princeton University; Dr. Waldeyer, professor of anatomy and director of the anatomical institute in the University of Berlin; Dr. Zeeman, professor of physics at Amsterdam.

The degree of LL.D. was conferred on Professor A. H. Purdue, by the University of Arkansas, upon his retirement from that institution in June. For sixteen years he had been professor of geology there, and *ex-officio* state geologist of Arkansas since 1907. He is now state geologist of Tennessee.

At the last annual commencement of Lehigh University the honorary degree of doctor of science was conferred on Dr. James E. Talmage, formerly professor of geology in the University of Utah, and on Mr. James Gayley, of New York City.

Washington College, Chestertown, Md., conferred the degree of doctor of science on Dr. J. S. Grasty, professor of geology at the University of Virginia, at the annual commencement, when Professor Grasty delivered the address to the students.

On the occasion of its fiftieth anniversary, the Belgian Chemical Society has elected as honorary members all those who have received the Nobel prize, namely, Messrs. Arrhenius, von Baeyer, Buchner, Fischer, Ostwald, Ramsay, Rutherford and Wallach and Mme. Curie.

Dr. Francis H. Champneys has been elected president of the Royal Society of Medicine, London.

Professor Jeremiah W. Jenks, of Cornell University, has been appointed financial adviser to the Chinese republic.

Dr. E. de Wildman has been appointed director of the Brussels Botanical Garden.

Mr. William Odling, M.A., F.R.S., has been elected an honorary fellow of Worcester College, Oxford, on his resignation of the Wayn-

flete professorship of chemistry after a tenure of forty years, and his consequent vacation of the professorial fellowship, which he has held for the same period at the college.

MR. WILLIAM MCDOUGALL, F.R.S., Wilde reader in mental philosophy at Oxford, has been elected an extraordinary fellow of Corpus Christi College.

IT is stated in *Nature* that the John Harling fellowship for the encouragement of the study and research in physical science, in the University of Manchester, has been awarded to Mr. H. G. J. Moseley, who was until recently an assistant lecturer and demonstrator in the department of physics in the university, and to Dr. T. S. Taylor, now instructor of physics in the University of Illinois.

M. ARMAND GAUTHIER, professor of chemistry in the medical faculty of the University of Paris, has retired.

PROFESSOR JOHANNES GAD, who last year retired from the professorship of physiology at Prague, has celebrated his seventieth birthday.

WE learn from *The Observatory* that Mr. B. D. Evans, computer at the Royal Observatory, Greenwich, has been appointed first assistant at the Hongkong Observatory. The director at Hongkong is now Mr. T. F. Claxton, formerly superintendent of the Mauritius Observatory, and previously on the staff of the magnetic and meteorological department at Greenwich. Mr. Jeffries, now the chief assistant, was also a member of the Greenwich staff.

DR. WILLIAM J. HICKSON, M.D., has been appointed director of the division of medical research in the department of research of the Vineland Training School, Vineland, New Jersey.

DR. J. C. ARTHUR, of Purdue University, gave a course of lectures on plant pathology, the first week in July at the Macbride Lakeside Laboratory, the summer school established by the alumni of the Iowa State University on Lake Okoboji, Iowa.

THE lecture to the Congress of the Royal Sanitary Institute, which will be held at York from July 29 to August 3, will be delivered by Professor Karl Pearson, F.R.S., his subject being "Eugenics and the Public Health." Professor H. R. Kenwood will give the popular lecture on "The Healthy Home."

DURING the past six months the value of the library of the Chemists' Club, New York City, has been notably increased, first by the generous gift of Mr. Herman Frasch of $10,000, an endowment fund the interest of which is to be used exclusively for the purchase of new books, and second by large gifts by Professor Chandler of 3,200 volumes, by Professor Mallet of 540 volumes and of approximately 700 volumes from members, publishers and authors.

A COMMITTEE has been formed with Mr. Austen Chamberlain as chairman to increase the endowment of the London School of Tropical Medicine. Subscriptions amounting to £15,000 have been received.

THE Paris Academy of Sciences has made seventeen grants for scientific research from the Rowland Bonaparte fund varying in amount from 2,000 to 3,000 francs.

THE Academy of Sciences, Letters and Arts of Bordeaux will celebrate the bi-centenary of its foundation on November 11 and 12 of the present year.

THE planks in the platforms of the Democratic and Republican parties in regard to public health are as follows. Democratic: "We reaffirm our previous declarations advocating the union and strengthening of the various governmental agencies relating to pure foods, quarantine, vital statistics and human health. Thus united and administered without partiality to or discrimination against any school of medicine or system of healing, they would constitute a single health service, not subordinated to any commercial or financial interests, but devoted exclusively to the conservation of human life and efficiency. Moreover, this health service should cooperate with the health agencies of our various states and cities without interference with their prerogatives, or with the freedom of individuals to employ such medical or hygienic aid as they may see fit." Republican: "It will strive not

only in the nation, but in the several states, to enact the necessary legislation to safeguard the public health; to limit effectively the labor of women and children; to protect wage-earners engaged in dangerous occupations; to enact comprehensive and generous workmen's compensation laws, in place of the present wasteful and unjust system of employers' liability, and in all possible ways to satisfy the just demand of the people for the study and solution of the complex and constantly changing problems of social welfare."

The German state returns of births and deaths in 1911 continue to confirm the characteristics of the returns for Prussia. In Würtemburg the excess of births over deaths was only about 25,000, as compared with more than 29,000 in 1910, and over 30,000 in previous years. In Würtemburg, at any rate, it is recognized that the downward tendency will continue, and the Statistical Office calculates that after 1915 there will be a reduction in the number of children for whom provision has to be made in the elementary schools.

The *Journal* of the American Medical Association states that the institute founded by the efforts of Professor His for biologic and therapeutic research on radium in the royal Charité has been opened. The aim of the institution is the investigation of the therapeutic effects of radio-active substances such as radium, mesothorium, radiothorium, etc., and their decomposition products. It possesses laboratories for chemical, zoological and botanical research and a complete equipment for physical measurements. In all there are about fifteen places for research workers. The institute is connected with a polyclinic in which internists, surgeons and other interested specialists will have opportunity to treat patients with radiation apparatus of various forms and strength, emanators for inhalation in closed rooms, apparatus for drinking the emanations, and other forms of application. The institute is founded through a fund appropriated by the Kaiser Wilhelm Society for Scientific Research, as well as by grants from various industrial companies. The management is in the hands of Privy Councilor His, whose representative is Dr. Gudzent. He is supported by a commission to which Professors Kraus, Orth, Lesser, Hildebrand, Bier, Zuntz, Hertwig, Hahn and Marckwald have assured their cooperation. Also a permanent physicochemical collaborator has been secured.

UNIVERSITY AND EDUCATIONAL NEWS

As has been stated in Science, the regents of the University of Michigan legislated for the reorganization of graduate studies, by providing for the establishment of an autonomous graduate department, to be governed by its own dean, and by an executive board of seven, together with the president, *ex officio*. The necessary appointments have now been made, as follows: Dr. K. E. Guthe, professor of physics, has been elected to the deanship, while the board is to consist of the president; Dr. M. E. Cooley, dean of the department of engineering; Dr. V. C. Vaughan, dean of the department of medicine; Dr. H. C. Adams, head of the department of political economy; Dr. R. M. Wenley, head of the department of philosophy; Dr. F. N. Scott, head of the department of rhetoric; Professor H. M. Bates, dean of the department of law, and Dr. M. Gomberg, professor of organic chemistry. The new executive will take office on October 1, and will probably devote next year to a thorough consideration of future policy.

Whitman College, Walla Walla, Washington, has received from seven hundred donors a fund amounting to more than $200,000.

St. Francis Xavier College is to be united with Fordham University, New York City. The St. Francis Xavier grammar and high school will be maintained.

The new four-year course which has been outlined by the College of Agriculture, of the University of Illinois, has the first year's work prescribed and one half of the work of each semester of the sophomore year. The remainder of the time is given over to specialization in soils, crops, agricultural teaching, horticulture, farm mechanics, dairying or ani-

mal husbandry. A new college circular describing this course will be ready for distribution about the middle of August.

SAMUEL L. BOOTHROYD, assistant professor of topographic and geodetic engineering in the College of Civil Engineering of Cornell University, has resigned to accept the associate professorship of astronomy and mathematics in the University of Washington, succeeding Professor James E. Gould. The trustees have promoted Paul Halladay Underwood, instructor in the college, to the rank of assistant professor and appointed him to the place vacated by Professor Boothroyd. The following appointments have also been made: Ransom E. Somers, instructor in economic geology; E. H. Kennard and T. B. Brown, assistants in physics, and R. A. Gulick, assistant in chemistry.

H. N. PARKER, of the Illinois Experiment Station, will head the division of sanitary dairying of the university next year. Professor B. R. Rickards will enter the employ of an Indianapolis manufacturing firm.

DR. ARTHUR E. HILL, of New York University, has been appointed professor of chemistry and director of the laboratory to succeed Professor Lamb.

GEORGE R. WELLS, Ph.D. (Hopkins, '12), has been appointed instructor in psychology at Oberlin College.

L. R. GEISSLER, Ph.D. (Cornell), has resigned his position as research psychologist in the Physical Laboratory of the National Electric Lamp Association, Cleveland, to become professor of psychology at the University of Georgia. He will organize and direct the new psychological laboratory to be established in connection with the School of Education. The laboratory will occupy seven or eight rooms in George Peabody Hall, the new home of the School of Education now under construction, and will be furnished with all modern equipment.

WILLIAM E. BARROWS, JR., has been appointed professor of electrical engineering at the University of Maine. For the past six years he has been assistant professor of electrical engineering at the Armour Institute of Technology.

DR. W. H. WARREN, connected during the past year with the department of chemistry of Clark College, has recently been appointed professor of chemistry in Wheaton College, Norton, Massachusetts.

PROFESSOR CHARLES E. DECKER, M.S. (Chicago), has been appointed assistant professor of geology and biology at Allegheny College.

DR. FRANK ELBERT WHEELOCK, instructor in physics in the University of Missouri, has been appointed professor of physics in Mount Allison College, Sackville, New Brunswick.

THE following appointments have been made in consequence of the new grant in the University of London made by the London County Council for the increase of the university professoriate: Dr. J. A. Fleming, D.Sc., F.R.S., professor of electrical engineering (to teach at University College); Dr. Arthur Dendy, D.Sc., F.R.S., professor of zoology (to teach at King's College).

PROFESSOR V. BJERKNES, of the University of Christiania, has been offered the chair of geophysics at Leipzig.

DR. JEAN BRUNHES, professor at Lausanne and Freiburg, has been called to the chair of anthropogeography in the Collège de France.

DISCUSSION AND CORRESPONDENCE

"GENES" NOT MADE IN GERMANY

TO THE EDITOR OF SCIENCE: The new version of "genes" in the issue of May 24 carries a reminder of Mark Twain's "jumping frog." Darwin's word pangen is taken into German to alter the vowel quantity and then comes back into English accompanied by a superfluous letter and a new system of philology elaborated to justify the "genes" and "pangenes" that adorn the pages of recent publications on genetics.

The custom has been to use Latin transliterations of Greek derivatives, but scientific literature is now to have a more Teutonic flavor. The new system need not be confined

to genetics, of course, nor even to biology. The same reasons can be urged for oxygene as for pangene. Scores of terms have been based on the same root, γεν, but hitherto with a short vowel, as in the Greek. Some philologists add a letter in forming such a word as clone, where the original Greek vowel is long, but this has nothing to do with Dr. Shull's "general law of English philology" that would lengthen short vowels to enable Greek derivatives to be pronounced with a German accent. In this case Johannsen's correct word "gen" was displaced by a linguistic monstrosity, "gene," because the latter was supposed to sound more like German, and because "the German word '*Pangen*' better expresses the meaning involved than does the English word 'pangen.'" The new final "e" symbolizes the magically improved connotation acquired by Darwin's word pangen in passing from English into the hallowed precincts of the German language. It replaces the italics, capitals and quotation marks otherwise required to differentiate the more expressive German "*Pangen*" from the ordinary English "pangen." The mistake, as now appears, was not a merely casual adoption of the German plural "*Gene*" as an English singular, but a deliberate substitution of an erroneous new singular "gene," anomalous alike in German, Greek or English. Dr. Shull does not state when, where or by whom this change from "gen" into "gene" was determined, but these details are of no importance now that the method has been explained. It would have been easier to bestow "gene" and "pangene" on the French, who use "*oxygène*" and a whole class of similar terms, but the German derivation is more ingenious.

Regarding the phenotypes, little need be said. Dr. Shull reasserts the reality of phenotypes, and even insists with italics that "statistical investigation may *discover, measure* and *describe* phenotypes." But if it be true that "phenotypes and genotypes exist among Mendelian hybrids," or elsewhere in nature, they must be the names of classes or groups of animal or plant individuals distinguished by the possession of certain characters or gens. Such group names are usually considered as collectives, but Dr. Shull maintains that phenotypes "must always be abstractions." Evidently the new science of genetics is to have an original system of metaphysics as well as of philology.

O. F. Cook

Bard, California,
June 17, 1912

Propositions for Changes in the International Code of Zoological Nomenclature

Attention of zoologists is invited to the rule that all propositions for changes to the International Code must be in the hands of the Commission at least one year before the meeting of the International Congress.

Formal notice of the exact date of meeting has not yet reached me, but I hope to have my first report to the Commission prepared for mailing not later than September 1. About that date I shall also send to Science and to the *Zoologischer Anzeiger* a complete list of the propositions that have been sent to me.

It is a great satisfaction to the Commission to note the increased and more general interest exhibited by zoologists in nomenclatorial matters, and I take the liberty of repeating a statement made on several former occasions, namely, that the Commission welcomes most heartily correspondence and suggestions from all zoologists.

C. W. Stiles,
Secretary, International Commission on Zoological Nomenclature

The Pei Yang University

To the Editor of Science: A note by Consul General S. S. Knabenshue, of Tientsin, China, regarding vacancies in the staff of the Pei Yang University, of that city, published in *Daily Consular and Trade Reports* of July 8, seems likely to deluge me with inquiries and applications, and I would be glad if you would aid me in forestalling them by publishing this statement. There are no vacancies in the staff of the Pei Yang University at

present, Dr. George I. Adams, of the United States Geological Survey, having been recently appointed to the chair of geology and mining, and Dr. H. V. Fuller, of Zürich University, to the chair of chemistry. Next year the professorship of railway engineering will be vacant, but only properly qualified persons should apply, as the university, though small, maintains a high standard and the salary offered is sufficient to command the services of able and experienced men. I have received many applications for positions which do not exist, and beg to point out that, as stated in SCIENCE, March 1, 1912, the professorships now filled by foreigners are: law, two; economics and history, one; chemistry, one; geology and mining, one; metallurgy, one; civil engineering, two; mechanical engineering, one; railroad engineering, one. As stated above, none of these are now vacant. There are no professorships in mathematics, physics, biology, zoology, botany, agriculture, pedagogy and kindred subjects, nor are any likely to be created.

THOMAS T. READ

SAN FRANCISCO, CAL.

SCIENTIFIC BOOKS

Technology and Industrial Efficiency. A Series of Papers Presented at the Congress of Technology, opened in Boston, Mass., April 10, 1911, in Celebration of the Fiftieth Anniversary of the Granting of a Charter to the Massachusetts Institute of Technology. McGraw-Hill Book Company. 1911. Pp. 486.

This volume of papers, covering a large variety of topics in applied science, derives its interest possibly as much from the occasion which has called it forth, as from its contents. The charter of the Massachusetts Institute of Technology was signed by Governor Andrew on April 10, 1861. The fiftieth anniversary of this event was taken advantage of for the inauguration of a congress of technology which lasted through several days, and to which the public was invited, to listen to the reading of papers contributed by graduates and professors of the institute.

The occasion was thus, in some degree, a celebration of the fiftieth anniversary of the institute, and a demonstration, so far as it was needed, of the prominent position in applied science which had been won by it and by its graduates.

It is an interesting question, in how short a time may an institution of learning, without substantial state aid or endowment, dependent almost wholly upon its own resources and the merits of what it has to offer, attain to a commanding position among institutions of learning? The lesson which has been taught by the institute is, in this respect, most instructive. Here is an institution which, in the short space of considerably less than fifty years, has become one of the leading institutions of its kind in this country or in the world, and it has attained this position solely by its own merits and exertions, with a small endowment, with little aid from the state—until within a very few years—and obliged to depend, therefore, for its maintenance and progress upon the tuition fees from students and such scattering gifts as it might receive from time to time. This position of leadership has already been held by the institute for at least fifteen or twenty years, so that from the date of the first small beginnings, when the classes met in hired quarters in the business section of the city of Boston, the school has developed in a third of a century into a position of unquestioned leadership.

Under these conditions it is not unnatural that its graduates, faculty and corporation should take advantage of the fiftieth anniversary of its birth to celebrate the progress which has been made. The papers presented at the congress have been edited and collected in the volume referred to above.

These papers, covering, as they do, the whole field of applied science, differ widely in character and subject. There are but few on any one topic, and the specialist will find but little in the volume to enlarge his detailed knowledge. Nevertheless, the papers have been kept somewhat non-technical in form and designed to be of general interest to the applied scientist, and this object has been ad-

mirably attained. The applied scientist, in whatever branch of engineering he may be engaged, will be able to read most of the papers with interest and profit, and will find that they will enlarge his view of the field of engineering. Many of them deal with the progress in certain branches of science within the last few years, giving a summary of the main events. There is little that is strictly technical in the volume, and the writer recalls but one paper which is accompanied by any mathematical formulæ.

The volume opens by a paper by President Maclauren, entitled "Some Factors in the Institute's Success." In this paper Dr. Maclauren outlines most admirably the main features which have contributed to the rapid and great success of this school. Among the important contributing elements he names the fact that the school was born in Boston, where the value of education was fully appreciated, and where the new venture received moral, if not immediate financial support; then the impetus which applied science had taken on at the time of its birth, owing to the great discoveries in engineering which had just preceded it; and finally, as a cause to which Dr. Maclauren attributes special importance, the fact that there has never been any uncertainty or indefiniteness as to what the institute is aiming at in its scheme of education. The institute was founded to emphasize *the importance of the useful,* using the term in its broadest sense and not limiting it simply to that which aids a man to earn his bread and butter, but understanding it to mean whatever cooperates in enabling a man to make his life of greater use to himself and to the community. As contrasted with the scholastic education which devotes itself to the abstract, and sometimes even decries that which is useful, the institute maintained that utility was the first object in the study of anything. In accordance with this idea, the method of teaching adopted at the institute has been termed "learning by doing," and Dr. Maclauren gives it as his belief "that the do-it-yourself method has been the greatest factor in the success of the institute." Whether this is true or not, there seems no question of the fact that the establishment of this school has had a great influence upon the traditional college education, and it probably is not too much to say that the trend in education to-day is in the direction in which the institute has always moved.

The technical papers in the volume are sixty-eight in number, averaging, therefore, only about seven pages in length. They are divided into six sections.

Section *A* deals with scientific investigation and the control of industrial processes, and contains seventeen papers, treating of such subjects as the conservation of metal resources, some causes of failure in metals, metallography, improvements in cotton bleaching, the gas industry, fire prevention, the utilization of blast furnace wastes, reclamation in the west and similar topics.

Section *B* treats of technological education in its relations to industrial development, and consists of thirteen short papers, several of which emphasize the importance of the method and aim at the institute, the value of a thorough training in engineering, and the influence of the institute upon education.

Section *C* treats of administration and management, and contains nine papers, several of them devoted to the modern subject of scientific management. One of these, entitled "An Object Lesson in Efficiency," is contributed by Mr. Lewis, president of the Tabor Manufacturing Company, of Philadelphia, the company in which the principles of Mr. F. W. Taylor have been most thoroughly carried out. The applicability of scientific management to various branches of industry are discussed in this section, and one of the most interesting papers in the volume is that of Mr. H. G. Bradlee, of the firm of Stone & Webster, entitled "A Consideration of Certain Limitations of Scientific Efficiency," in which he points out the fact that scientific management has distinct limitations which, at the present time, we may be apt to overlook. We are an hysterical nation, and the pendulum swings rapidly from extreme to extreme. After reading the highly colored ac-

counts of the results attained by scientific management as depicted by some of its enthusiasts, and after being solemly assured that the railroads of this country could save a million dollars a day by introducing the principles of scientific management, it is refreshing to read a calm, dispassionate, but keenly analytical paper like that of Mr. Bradlee, and, after finishing it we shall find ourselves less enthusiastic but more sane.

Another important paper in this section is that contributed by Mr. S. M. Felton, president of the Chicago Great Western Railroad, on the scientific management of American railways. This is the longest paper in the volume covering, with cuts, 46 pages. It gives a very interesting account of the development of American railways since 1850, with cuts illustrating the differences between rolling stock at the present time and forty or fifty years ago, and many interesting facts, figures and historical comparisons, both as to the physical characteristics of railways and the operating results.

Section *D* treats of recent industrial development, and includes 15 papers treating of improvements in electric lighting, illuminating engineering, gasolene engines, electric propulsion, the mechanical handling of materials and mail, electro-chemistry power plants, ore-dressing, etc.

Section *E* treats of public health and sanitation, and contains nine papers. This section is especially indicative of the work of the institute, for this school, it is fair to say, has been the leader in the training of sanitary engineers. The graduates from its department of sanitary engineering have taken a foremost part in the modern improvements in methods of water supply, filtration, and sewage disposal, and are found occupying positions of responsibility all over the country. The part that the institute has played in this development is traced in one of these papers by Professor George C. Whipple, himself one of the most eminent examples of the leadership of the institute in this department. Another paper, by Professor Phelps, gives an account of the work of the sanitary research laboratory and sewage experiment station, a novel and important adjunct of the institute.

Section *F* is devoted to architecture. In comparison with the splendid architectural department of the institute and the eminence of the men who have graduated therefrom, this section is the least satisfactory in the volume. It contains but four papers, two of them written by civil engineering graduates, and one by a mechanical engineering graduate, only one being contributed by a graduate in architecture. Possibly this is due to the fact that in pure architecture there may have been less development in recent years than in the other branches of applied science, most of the improvements in the construction of buildings having been of an engineering rather than of an architectural nature.

As a whole, the volume will well repay reading. Almost everybody will find material of interest in it, and will be struck with the excellence of the papers as a whole, and especially by the fact that one institution should, in so short a time, have been able to turn out so many men who have attained to leading positions as applied scientists. In this respect, however, the volume is almost as noticeable for the names that are absent as for those that are represented among the authors. Some of the most eminent of the institute graduates have not contributed papers, and it is probably safe to say that the school is quite capable of producing another similar volume of equal size and equal interest. GEO. F. SWAIN

The Mechanics of Building Construction. By HENRY ADAMS, M.Inst.C.E., M.I.Mech.E., F.S.I., F.R.San.I., M.S.A., etc. Longmans, Green, and Co. Cloth; $5\frac{1}{2} \times 9$ in. Pp. xi + 240; 589 figures. $2 net.

A rare combination of qualities is requisite to the authorship of a really good engineering text book. In addition to the literary polish of the novelist one must have the broad point of view of the practising engineer as well as the didactic skill supposed to characterize the college professor. The author of this book is an engineer who has received many tokens of confidence and esteem from his fellow engi-

neers, he has written many papers and books and for thirty-five years he was a college professor. His product, however, can hardly be called a really good book.

The author is chief examiner on engineering for the London Board of Education. At the request of this board a few years ago he gave to a group of teachers a series of lectures upon the "Mechanics of Building Construction, with the object of perfecting their knowledge of the subject and at the same time illustrating the manner in which it should be taught." These lectures have been expanded and form the basis of the present text.

In giving the original lectures and in this work of revision it may be conjectured that the author's duties as examiner were ever present in his mind and unconsciously influenced his style of writing. The attempt is made to explain methods of estimating the strength of all structural parts met in English building practise. The method chosen is generally that of working out particular problems rather than developing the principles involved. In those parts where some attempt has been made to develop principles, the writing seems very careless. In some cases the simplest things are explained and some of the important ones are omitted. While a considerable portion of the book naturally has to do with flexure, the simple principles of the theory of flexure are not given. It is apparent that the writer has not had the same class of readers in mind while he was writing different parts of the text.

The book will doubtless be of assistance to the men who are preparing for the examinations referred to. It can hardly be recommended to the general student. It seems, however, especially well fitted for the use of an architect or builder who has taken up his work without a proper education; his familiarity with the subjects treated will enable him to read the parts in which he is interested with some understanding; but it is a question whether such a man should be encouraged to make his own calculations unless he is willing to begin at the beginning in his study of the subject; otherwise it is almost certain that he will make mistakes due to the fragmentary character of his information.

The book is arbitrarily divided into thirty lectures for the supposed convenience of teachers who, while giving lectures upon the subject, may wish to follow the author in a servile manner. Graphical solutions are used throughout in preference to algebraic solutions; the figures illustrating the text are very numerous. The subjects treated cover fairly well the simpler problems likely to be met in building work in England; they do not include steel building construction as practised in America.

O. H. Basquin
Northwestern University

The Evolution of the Vertebrates and their Kin. By William Patten, Ph.D. Philadelphia, P. Blakiston's Son and Co. 1912. Pp. xxi + 481.

Twenty-two years ago there appeared in the same number of the *Quarterly Journal of Microscopical Science* two papers, one by Professor Gaskell and the other by Professor Patten, both maintaining the inadequacy of all the theories that up to that time had been proposed to account for the origin of the vertebrates and advocating a new one, namely, the derivation of the vertebrate phylum from crustacean-like ancestors. For more than two decades both authors have devoted themselves to working out the details of their theories and we now have the results of their labors collected into single volumes, that by Professor Gaskell having appeared about a year ago, while that of Professor Patten now lies before us.

It must be confessed that a certain amount of scepticism will obtrude itself into the consideration of both works, not from any predilection for older theories, but on account of the fact that on a common foundation the two authors have built up systems of homologies utterly incompatible the one with the other, the result being that the reader, despairing in his search for the truth in either system, is inclined to cry with Mercutio, "A plague o' both your houses." Professor Patten's views,

however, will on the whole prove the more acceptable to morphologists, since they do not show the utter disregard of certain fundamental principles of embryology so characteristic of Professor Gaskell's theory.

Professor Patten, as is well known, traces the vertebrate phylum back to an arachnid ancestry, represented by such forms as the Eurypterids, and thence traces it upwards through the Ostracoderms to the primitive arthrodire, dipnoan and amphibian forms. It will not be possible here to discuss the various homologies of arachnidan and vertebrate structures proposed in the book, such as the identification of the arachnidan limbs with the vertebrate external gills, of the arachnidan liver lobes with the vertebrate pharyngeal pouches and thyreoid, of the lemmatochord with the notochord. Nor can more than mention be made of the comparison of the lateral and parietal eyes of the arachnids with the corresponding structures in vertebrates, or of the suggestive similarity of the endocranium and branchial cartilages of *Limulus* to those of the vertebrates. But attention may be especially directed to two points that seem to be crucial for the theory, namely, the homologies of the surfaces of the body and the mode of evolution of the vertebrate brain.

The hæmal and neural surfaces of the vertebrate descendant are homologized with the same surfaces of the invertebrate ancestor whose appendages have migrated hæmally until their basal portions form the branchial arches and whose mouth has been supplanted by a new one, so that the stomodæum no longer perforates the central nervous system. A portion of the original stomodæum has become the ependymal lining of the third ventricle, another portion of it is represented by the infundibulum and hypophysis, and the new mouth is formed from what Professor Patten terms the cephalic navel, the region where in *Limulus* the blastoderm completes its investment of the yolk and which is identified with the dorsal organ of other arthropods. The cause of the closure of the original mouth Professor Patten finds in the constriction of the stomodæum by the consolidation and enlargement of the cephalic neuromeres and the evident difficulty in the way of imagining such a "cataclysmic metamorphosis," as Professor Patten rightly calls the closure of one mouth and the opening of another, he endeavors to avoid by the suggestion that it took place "during the embryonic, or larval period, the increasing volume of the yolk sphere making . . . (it) possible." In other words, he suggests that the closing of one mouth, the development of another, the transfer of the oral arches to the hæmal side and the appearance of true gill clefts all took place in the course of the life history of a single generation! Or should it be of a single individual?

With regard to the second point referred to above, Professor Patten holds that the entire arachnidan nervous system is equivalent to the vertebrate brain, the spinal cord being a later development which does not and probably never did show a division into neuromeres. But, it may be remarked in passing, in the vertebrate brain thus formed are included the hypoglossal segments, the hypoglossal nerve being the result of the segregation of special fibers from the vagus complex supplying the gills. The hypoglossal segments are, accordingly, primary constituents of the vertebrate brain, a view entirely at variance with the results of vertebrate morphology. The arachnidan fore brain consists of that portion of the brain situated in front of the stomodæum and is composed of three neuromeres. The first of these is associated with the olfactory organ and represents the olfactory lobes; the second is associated with the lateral eyes and its mushroom bodies become the cerebral hemispheres, while behind the third neuromere lies the stomodæal commissure, which is the representative of the vertebrate cerebellum! The medulla oblongata corresponds, however, to the abdominal or branchial portion of the nervous system of *Limulus* and, therefore, there is no correspondence whatever between the neural and hæmal surfaces of the vertebrate brain as far back as the region of the cerebellum, the neural surface of all this portion of the brain, including the hemispheres, the roof of the tweenbrain,

the optic lobes and the cerebellum, being derived from the procephalic neuromeres and having been carried caudally by the enlargement of the cerebral hemispheres and the optic lobes. Surely one might expect to find some indications of such a remarkable translocation in the ontogeny of the vertebrate brain, and yet one will look for it in vain. If it has occurred we must leave it to the neurologists to frame an explanation of the connections of the cerebellum.

This translocation is an essential part of Professor Patten's theory and with its accuracy and that of the supposed new-formation of the mouth the theory must stand or fall. While one may admire the ingenuity displayed in discovering unexpected homologies, one must acknowledge a feeling that in many cases they but create difficulties greater even than those they were intended to obviate. Nor does one find in the theory any explanation of the most essential feature of the vertebrate nervous system, namely, its arrangement in longitudinal zones corresponding to the nerve components. Indeed, the theory makes such an arrangement impossible, and yet an explanation of this arrangement and associated structural peculiarities must be an essential part of any acceptable theory of vertebrate phylogenesis.

But while the theory must be adjudged to be at least "not proven," it must be pointed out that Professor Patten in the study of the problem has added extensively to our knowledge of the morphology of the primitive arachnids and of the Arthrostraca, an account of the latter, based very largely on the study of material contained in Professor Patten's private collection, forming one of the most interesting chapters of the book. The concluding chapters are a discussion of the author's views as to the phylogeny of the various vertebrate and invertebrate groups, summed up in a concluding phylogenetic tree. Even though one may not agree with the author's conclusions, this portion, as well as the rest of the book, will be found well worth careful study by all morphologists.

It is to be regretted that the author has not taken more pains to render the reading of the book less tedious. Not but that the presentation is satisfactory, barring many annoying orthographical errors, and the numerous illustrations are excellent both in execution and reproduction. But rarely is a figure to be found on the page where it is referred to and the reader becomes wearied turning backwards and forwards to find the figure to which his attention is directed, only to discover, when he has located it, that he must turn again to the end of the book to find an explanation of the lettering employed. And even then he will not always find what he is looking for. The index, too, is decidedly inadequate.

J. P. McM.

SCIENTIFIC JOURNALS AND ARTICLES

The contents of the June issue of *Terrestrial Magnetism and Atmospheric Electricity* include:

"The Penetrating Radiation," W. W. Strong.

"Results of some Long Series of Magnetic Observatory Observations: Colaba (1846–1905), Pola (1847–1909) and Potsdam (1892–1900)," reviewed by D. L. Hazard.

"The Physical Theory of the Earth's Magnetic and Electric Phenomena, No. V.: On the Formation of the Earth's Magnetic Field," L. A. Bauer.

"Magnetic Declinations and Chart Corrections in the Atlantic Ocean according to the Observations on Board the *Carnegie*, June, 1910, to March, 1911," L. A. Bauer and W. J. Peters.

BOTANICAL NOTES

Laboratory botanists who are looking for a constant temperature apparatus will do well to read W. J. S. Land's paper on this subject in *The Botanical Gazette* for November, 1911, where the descriptions are illustrated by working drawings quite sufficient to enable a good workman to reproduce the apparatus at much less cost than otherwise.

Botanists will read "The Wilting Coefficient for Different Plants and its Indirect Determination," by L. J. Briggs and H. L. Shantz (Bull. 230, Bureau of Plant Industry, U. S. Dept. Agriculture), for two purposes: (1) The very considerable amount of valuable

physiological and ecological information contained in the paper, and (2) for the descriptions and illustrations of the very ingenious apparatus devised and used by the two investigators. For the latter especially the paper is to be very highly recommended to teachers of plant physiology who are in search of effective apparatus.

PLANT physiologists will find some surprising things in "A Preliminary Study of the Forced Curing of Lemons as Practised in California," by A. F. Sievers and R. H. True (Bull. 232, Bureau of Plant Industry, U. S. Dept. Agriculture, Feb., 1912). Lemons that ripen on the tree, known as "tree-ripes," constitute as a whole, "an inferior class of fruit, both as to appearance and keeping quality, and are largely consumed in near-by markets." They are therefore picked when full-grown but still uniformly green in color, and then cured in the packing house, and it is said that when so cured the lemon "has a better appearance, better keeping quality, and a considerably thinner rind." The reading of some portions at least of this bulletin is commended to plant physiologists.

WHILE the foregoing bulletin appeals to the plant physiologist, one from the California Experiment Station (No. 196) on the "Tolerance of *Eucalyptus* for Alkali," by R. H. Loughridge, is of especial interest to the ecologist. The increasing growth of *Eucalyptus* trees of various species raised the question of the possibility of utilizing the alkali lands for such plantings, and the experiment station was asked to furnish the necessary information as to the tolerance of different species of *Eucalyptus* for the ordinary alkali salts of the soil. It appears from this bulletin that it is possible to grow good trees of several species of *Eucalyptus* upon soil which has much alkali in it, and that there is a very considerable difference in the tolerance of the different species for alkali.

DR. B. M. DAVIS'S paper on the "Reduction Divisions of *Oenothera lamarckiana* and *O. gigas*" (*Ann. Bot.*, October, 1911) adds to the cytology of these related forms in which the number of chromosomes in the second is twice that of the first, the author affirming as one of his conclusions that "*O. gigas* is a progressive mutant, its peculiarities being clearly associated with the changes in its germ-plasm incident upon the doubling of its chromosome number." Seventy-nine figures on three double plates illustrate the paper.

DR. J. M. COULTER has been studying the endosperm of Angiosperms (*Bot. Gaz.*, November, 1911) and decides definitely in favor of its gametophytic nature in spite of the various nuclear fusions from which some have argued its sporophytic character. "The product of such fusions as do occur is merely an undifferentiated tissue, which practically continues the tissue of the gametophyte; that is, it is simply *growth* and not *organization*."

L. W. SHARP described (*Bot. Gaz.*, September, 1911) the embryo sac of *Physostegia* in which a curious lateral lobe develops in the antipodal region and in this eventually the endosperm forms, and into it also the embryo protrudes by the great elongation of the micropylar cell of the proembryo.

THE same author and W. H. Brown publish (*Bot. Gaz.*, December, 1911) their study of the embryo sac of *Epipactis* which differs in certain details from the usual structural sequence.

N. E. STEVENS in the December (1911) *Torrey Bulletin* publishes a paper on the "Dioecism of the Trailing Arbutus (*Epigea*)" in which he shows first that it is not properly heterostylous, in spite of the fact that there is much difference in the length of the styles. On the other hand, he found that it is functionally dioecious.

A VALUABLE SERVICE TO SCIENCE

THE Historical Department of Iowa has rendered a most valuable service to science by procuring the preparation and publication of a sketch of the life of the naturalist, Rafinesque, accompanied by a voluminous bibliog-

raphy of his many publications. In the volume entitled "Rafinesque, A Sketch of his Life with Bibliography," by Professor T. J. Fitzpatrick, we have placed before us a most readable account of the life of this gifted and eccentric man, who was so tireless a student and observer of nature. To this part of the book fifty pages are given, every page of which is full of interest. Born of French and German ancestry in a suburb of Constantinople in 1783, he lived mostly in France until 1802, when he came to America, remaining several years. Returning to southern Europe for a period, he finally came again to America, where he remained until his death in 1840.

The story of his life is told with absorbing interest and no one can run over these pages without feeling grateful to the writer who has made the eccentric hero of the story live again for us, and we may hope that many who read it will be inclined to think less harshly of his work, done, as it was, in a period when science was little recognized in this country.

The Bibliography will be a revelation to many scientific men who have known about Rafinesque only in a general way. All told the list includes 941 titles. The author says in his introduction that "the writings of Rafinesque are varied and widely scattered," and refers to the difficulty he experienced in collecting the material upon which his list is based. The list consists of titles, dates, places of publication and notes, the latter often very interesting as including historical facts not to be found elsewhere. Here and there one finds a photographic reproduction of a title page, often very quaint and old-fashioned.

After the regular bibliography a few pages are given to a list of 134 articles that refer to Rafinesque, some rather fully, and others only incidentally. The book closes with a short chapter on the portraits of Rafinesque.

One can not turn from a reading of this book of Professor Fitzpatrick's without feeling that in Rafinesque American science had a man of far more than ordinary ability, and that while eccentric and erratic he has still to be reckoned with as one who studied nature and found out many of her secrets, in the early days when naturalists were few and far between. And science owes much to the author and the Historical Department of Iowa for bringing together all this information and issuing it in this very attractive volume.

Charles E. Bessey
The University of Nebraska

SPECIAL ARTICLES

THE HISTORY OF THE GERM CELLS IN THE PÆDOGENETIC LARVA OF MIASTOR

Six years ago, when I began to study the origin of the germ cells in insects, an attempt was made to obtain specimens of the pædogenetic larvæ of certain flies belonging to the family Cecidomyiidæ. At that time I was informed by one of the best authorities on the Diptera that there were none in this country. Since then they have been discovered (October 5, 1910) by Dr. E. P. Felt and many features of their life history have been determined by him.[1] I am indebted to Dr. Felt for an abundant supply of these interesting larvæ, upon which work is now progressing.

As early as 1865 the fact that the germ cells (pole cells) of the pædogenetic Cecidomyiidæ are set aside very early in embryonic development was pointed out by Leuckart[2] and Metschnikoff.[3] Their brief descriptions were followed a year later by a more detailed account.[4] Eggs were found containing only two nuclei which were supposed to result from the division of the germinal vesicle. These nuclei continued to give rise to others by division

[1] Felt, E. P., "Miastor and Embryology," Science, Vol. 33, pp. 302–303, 1911; "Miastor Americana, Felt; an Account of Pedogenesis," Bul. 147, N. Y. State Museum, pp. 82–104, 1911; "Miastor," *Journ. Ec. Ent.*, Vol. 4, p. 414, 1911.

[2] Leuckart, R., "Die ungeschlechtliche Fortpflanzung der Cecidomyienlarven," *Arch. f. Naturg.*, Bd. 1, 1865.

[3] Metschnikoff, E., "Ueber die Entwicklung der Cecidomyienlarven aus dem Pseudovum," *Arch. f. Naturg.*, Bd. 1, 1865.

[4] Metschnikoff, E., "Embryologische Studien an Insekten," *Zeit. f. Wiss. Zool.*, Bd. 16, 1886.

until twelve to fifteen were produced, one of which, lying at the pointed pole of the pseudovum, became surrounded by a thick, dark yolk mass and with it separated as a distinct membraneless cell, the first pole-cell. This then divided into two and later into four cells. These four then separated into two groups of two cells each and were recognized as the

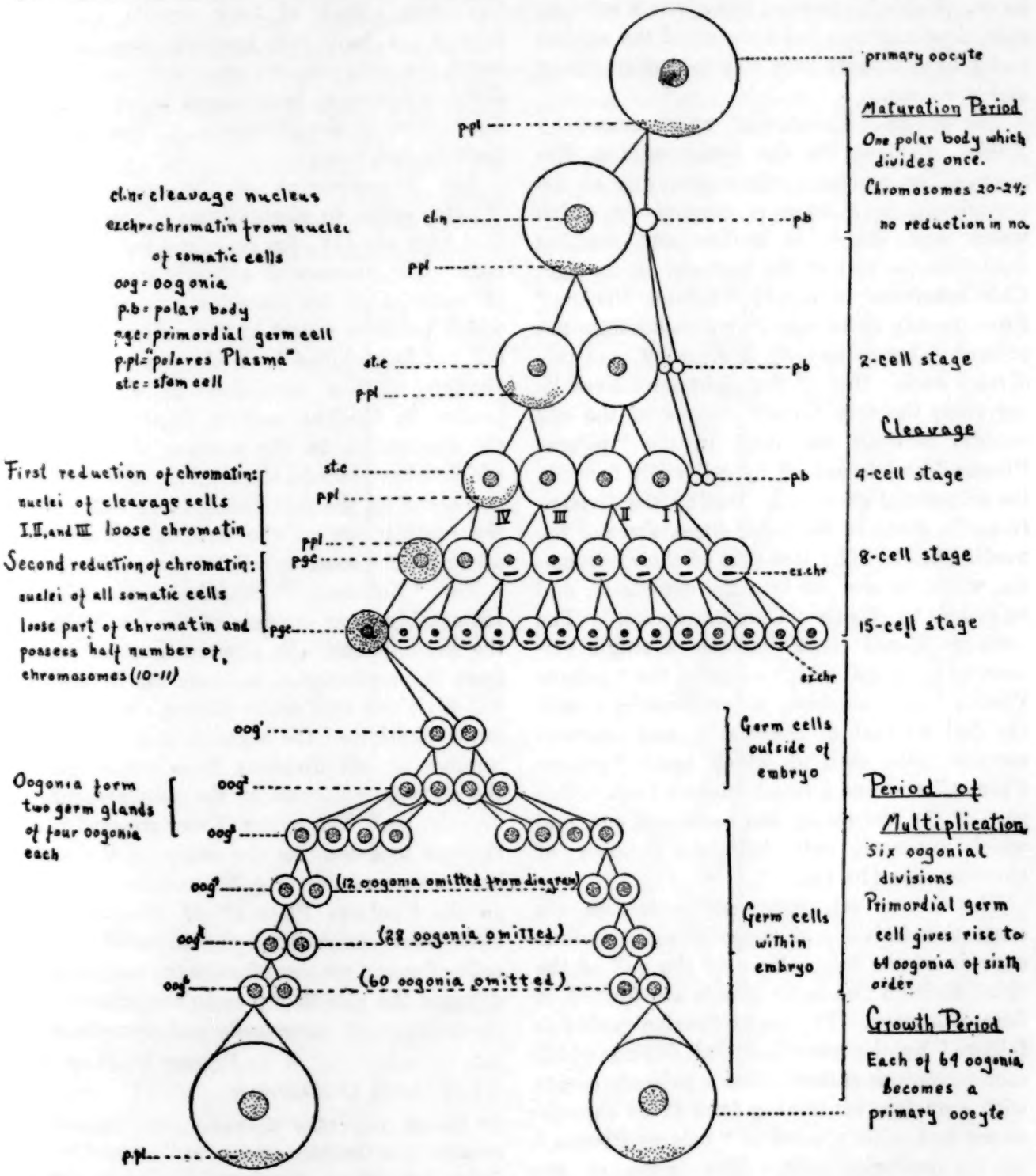

FIG. 1.

primitive reproductive organs lying in their definitive positions. From 1866 until 1908 nothing was added to our knowledge of the embryonic development of these pædogenetic larvæ. Kahle,[5] however, has given a remarkably clear and detailed account of the subject and I have already been able to confirm many of his results.

The entire "Keimbahn," as described by Kahle, is shown in the accompanying diagram. The primary oocyte contains, at the posterior pole, a mass of protoplasm which stains more deeply in aniline and carmine than does the rest of the material in the egg. This substance is named "polares Plasma." From twenty to twenty-four chromosomes are present. One polar body is given off, and this divides once. One of the eight nuclei resulting from the first three divisions of the egg nucleus becomes embedded in the "polares Plasma" and is cut off by cell walls forming the primordial germ cell. During the division from the 4-cell to the 8-cell stage, three of the nuclei (I., II., III.) lose part of their chromatin, which is cast off into the cytoplasm, and is called by Kahle "Chromatinreste." The next, or 15-cell stage, includes a single primordial germ cell which contains the "polares Plasma" and possesses a large nucleus with the full amount of chromatin, and fourteen somatic cells, each of which lacks "polares Plasma," and has a small nucleus from which part of the chromatin has been cast out, and which possesses only half the number of chromosomes (10–11).

The primordial germ cell undergoes six successive divisions, thus producing sixty-four oogonia of the 6th order. At the end of the third division two germ glands are formed of four cells each. The multiplication period is followed by the growth period during which each oogonium enlarges into a primary oocyte with a nucleus containing from 21–24 chromosomes and with a mass of "polares Plasma" at the posterior pole. The origin of the "polares Plasma" was not discovered.

Miastor americana Felt agrees so far as I have been able to determine with the species studied by Kahle (*Miaster metraloas*). The "polares Plasma" is present; the primordial germ cell is set aside at the 8-cell stage; and two germ glands of four oogonia each are formed. I have not, however, been able to count the chromosomes accurately nor to find division figures of early stages which show the diminution of the chromatin. These stages I hope to find later.

The determination of the germ cells of *Miastor* seems to combine two of the methods that have already been described for other animals. The presence of a deeply staining mass of material at the posterior pole of the egg, which becomes a part of the primordial germ cell but is excluded from the somatic cells, is similar to the condition in Chrysomelid beetles, in *Cyclops,* and in *Sagitta;*[6] whereas the diminution in the amount of chromatin which takes place in the somatic cells but does not occur in the primordial germ cell is like the casting out of the chromatin from the nuclei of the somatic cells of *Ascaris.*[7]

The "Keimbahn" of *Miastor* furnishes a remarkably clear example of the continuity of the germ plasm. It likewise enables us, at least in one instance, to state the number of cell divisions that occur during the period of multiplication of the oogonia, and, indeed, the number of cell divisions from one oocyte to the sixty-four oocytes of the next generation, namely, ten. The writer is now engaged in an attempt to determine the origin of the peculiar substances (germ cell determinants) such as the "polares Plasma" of *Miastor* which have been observed in the primordial germ cells of many species of animals, and hopes to discover the rôle they play in the primary differentiation of germ cells and somatic cells.

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[5] Kahle, W., "Die Paedogenesis der Cecidomyiden," *Zoologica,* Heft 55, pp. 1–80, 1908.

[6] Hegner, R. W., "Germ Cell Determinants and their Significance," *Am. Nat.,* Vol. 45, pp. 385–397, 1911.

[7] Boveri, Th., "Die Entstehung des Gegensatzes zwischen den Geschlechtszellen und den somatischen Zellen bei *Ascaris megalocephala,*" *Setz. Ges. f. Morph. Physiol.,* Bd. 8, 1892.

AN AUTOCOLLIMATING MOUNTING FOR A CONCAVE GRATING[1]

THE usual form of mounting for a concave grating is cumbersome and has the objection that either the receiving apparatus or the source must be movable. This may be avoided by employing the method of autocollimation, using that part of the light which after being diffracted is returned toward the slit. If therefore the slit is on Rowland's circle, the spectrum will be formed on the same circle and one point of it will coincide with the slit (Fig. 1). The wave-length of the light which

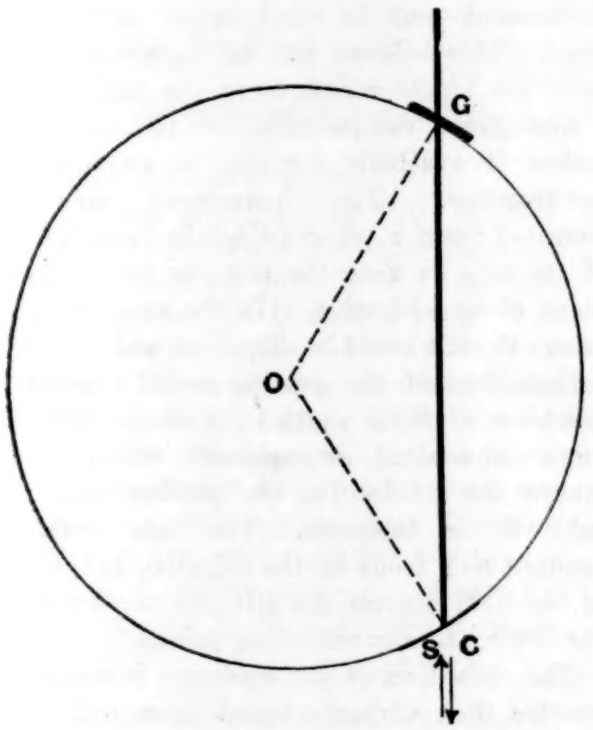

FIG. 1

is returned to the slit is given by the formula

$$\lambda = (2e/m) \sin \phi,$$

where e is the distance between consecutive rulings, ϕ the angle made by the light with the grating-normal, and m the order of the spectrum. It follows that at a given angle the order is twice that which is produced at the center of curvature.[2]

[1] Abstract of a paper read before the American Philosophical Society, April 20, 1912.

[2] The application of autocollimation to the concave grating was first described by A. Eagle, *Astrophys. Jour.*, 31, p. 120, 1910.

In this method, since the focal length changes in passing through the spectra, not only the inclination of the grating, but also its distance from the slit, must be altered. In addition the focal plane, which coincides with the arc of Rowland's circle, is inclined to the direction of the light by the same angle as the grating, and therefore the inclination of the camera must be changed to correspond with that of the grating. See Fig. 1, where G is the grating, S the slit, and the arc at C represents the position of the photographic plate in the camera.

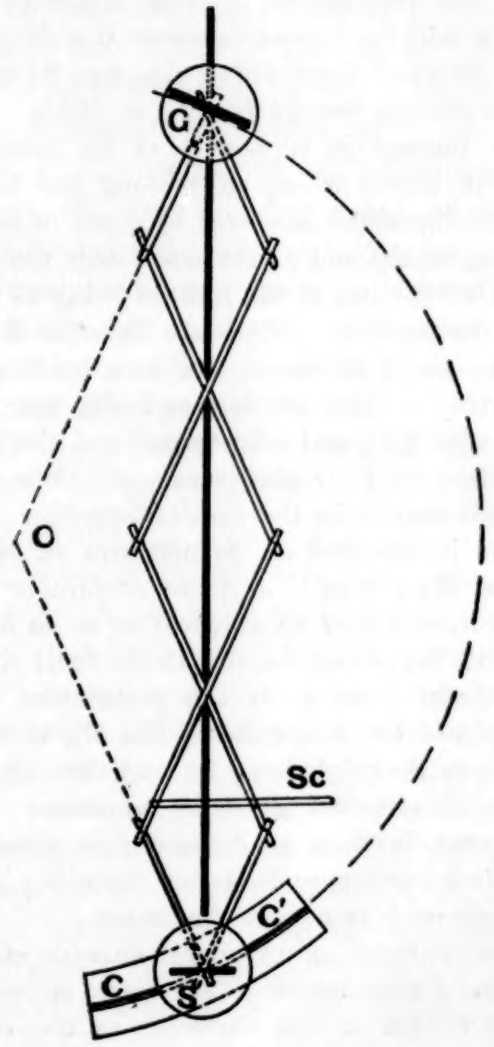

FIG. 2

In the instrument here described these adjustments are automatically made in the following manner. The grating is carried on a platform which slides along a horizontal track GS (Fig. 2) and is also capable of rotation

about a vertical axis through its center. At one end of the track is a fixed vertical axis, carrying a platform S for the slit and another CC' for the camera, both capable of rotation. The two axes are joined by a system of link bars of the "lazy-tongs" type, the total length of which, when fully extended, is equal to ρ, the radius of the grating. It is obvious that when the inclination of the bars to the track is ϕ, the distance GS will be $\rho \cos \phi$. If then the first and last bars of the linkage on one side are connected to the camera and grating so as to be parallel respectively to their normals, the inclination of both camera and grating will be correct however the distance GS is altered. Since either side may be used, all the grating spectra become available.

The linkage is supported at its intersections by blocks which slide along the track. The grating slider is moved by a rod or screw running to the end of the track near the slit, the only function of the linkage being to produce the necessary rotation. There is therefore no great stress on the axes tending to bend them. The grating and slit are provided with the usual adjustments and also may be shifted on their platforms until their centers fall exactly in the axes of rotation. The camera is mounted on its platform on either side of the slit at C or C' or preferably just above it, and may be adjusted so as to bring the plate into coincidence with the focal circle. For visual observation the plateholder may be replaced by an eyepiece. The slit is made double so that light may be sent through one part and returned through the other. The apparatus is thus available for a threefold use, as a spectrograph, as an observing spectroscope, and as a monochromator.

The diagonal of any parallelogram of the linkage perpendicular to the track is proportional to $\sin \phi$, and therefore to the wave-length. A scale of equal parts placed across any part of the linkage perpendicular to the track, as Sc (Fig. 2), will, therefore, give an approximate measure of the wave-length. A more open scale may be placed on the track, but this will not be one of equal parts.

As everything is supported upon one track, the apparatus may be made quite rigid, and at the same time, with the smaller gratings at least, portable. It will take up much less space than the other mountings. It is also more convenient, as everything is in reach at the same time from the end of the track—source, slit, camera and handle for controlling the position of the grating. There is but one track to make true, and the other adjustments are no more difficult, and in some cases much easier, than in the Rowland mounting. A very desirable feature is that the slit, grating and camera may be connected by a light-proof bellows or other enclosure, so that the instrument may be used in an undarkened room. This bellows may be supported partly upon the blocks which carry the linkage.

The great compactness of the mounting makes it available for use in astronomical spectroscopy. The instrument may be mounted upon a telescope in the prolongation of its axis so that the slit lies in the focal plane of the objective. (In the case of a star image the slit could be dispensed with, and the astigmatism of the grating would produce a spectrum of finite width.) A more rigid and more convenient arrangement would be to mount the guides for the grating upon the tube of the telescope. The light could be brought to a focus by the objective at the side of the field nearest the slit and thrown upon the slit by totally reflecting prisms.

The definition of the spectrum is somewhat greater than with the usual mounting, when spectra of the same order are compared. Moreover twice as many orders on each side may be observed. The principal disadvantages are that the scale of the spectra is not constant, so that the spectra are not normal. The deviations, however, are quite small and may be accurately allowed for. Another objection is the inclination of the plate, which requires special care in its register. These objections, which are shared by prism spectrographs, are much less serious when comparison spectra are used on the same plate.

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